Fault Tolerance in Distributed Systems: An Introduction

Distributed Systems
Sistemi Distribuiti

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Academic Year 2013/2014

Outline

These Slides Contain Material from [Tanenbaum and van Steen, 2007]

Slides were made kindly available by the authors of the book

- Such slides shortly introduced the topics developed in the book [Tanenbaum and van Steen, 2007] adopted here as the main book of the course
- Some of the material from those slides has been re-used in the following, and integrated with new material according to the personal view of the teacher of this course
- Every problem or mistake contained in these slides, however, should be attributed to the sole responsibility of the teacher of this course

Outline

Failure in Distributed Systems

Partial failure

- A typical feature of distributed systems is the notion of *partial failure*
- One component may fail, while the rest of the systems keeps running
- While the functionality guaranteed by the failed component is compromised, this does not necessarily holds for the other components, as well as for the overall system

Failure in Distributed Systems

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Engineering distributed systems with failure

- When engineering a distributed systems, a twofold goal is possible
  - reducing the impact of failure of a single component on the others, and on the overall system performance
  - exploiting partial failure to recover from failure

Outline

Dependable Systems

Main features of dependable systems

- Availability
- Reliability
- Safety
- Maintainability

Dependability is closely related to fault tolerance

Availability

Definition

Availability refers to the property that a system is ready for immediate use

Availability

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This means...

- ... that availability refers to the probability that a system is operating correctly at any given moment, ready to provide users with its functions
- So, a highly-available system is a system that is most likely to be ready and working at any given instant of time

Reliability

Definition

Reliability refers to the property that a system can run continuously without failure

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Definition

Reliability refers to the property that a system can run continuously without failure

This means...

- ... that reliability is defined in terms of a time interval, rather than of a instant – as in the case of availability
- So, a highly-reliable system is a system that is most likely to keep on running for a long period of time

Safety

Definition

Safety refers to the situation that when a system temporarily fails to operate correctly, nothing catastrophic happens

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This is...

- ... a very difficult property to be defined, and to be ensured as well

Maintainability

Definition

Maintainability refers to how easily a failed systems can be repaired

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This means...

- ... that maintainability is closely related to availability
- So, a highly-maintainable system may also show a high degree of availability

Faults I

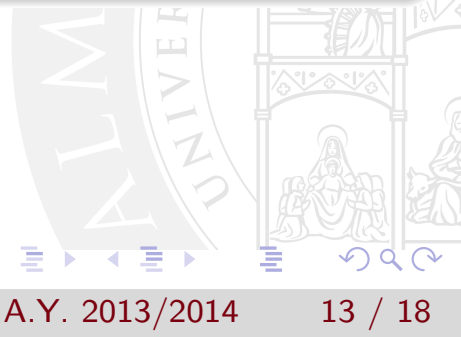
Failure

- A system is said to *fail* when does not behave as promised
- An *error* is a part of a system state that might have caused a failure
- The cause of an error is a *fault*

Faults II

Fault tolerance and dependable systems

- Building a dependable system closely relates to controlling faults
- One may distinguish between
  - preventing faults
  - removing faults
  - forecasting faults
- In distributed system, the most important issue is *fault tolerance*
- as the property of a system to provide its function even in the presence of faults



Faults III

Sorts of faults

- *Transient faults* occur once then disappear
- *Intermittent faults* occur, vanishes of its own accord, then reappears, and so on
- *Permanent faults* keep on existing until the faulty component is replaced /fixed

Failure Models

Type of failure	Description
Crash failure	A server halts, but is working correctly until it halts
Omission failure *Receive omission* *Send omission*	A server fails to respond to incoming requests A server fails to receive incoming messages A server fails to send messages
Timing failure	A server's response lies outside the specified time interval
Response failure *Value failure* *State transition failure*	A server's response is incorrect The value of the response is wrong The server deviates from the correct flow of control
Arbitrary failure	A server may produce arbitrary responses at arbitrary times

Different types of failures
[Tanenbaum and van Steen, 2007]

Failure Masking by Redundancy

Idea

- Hiding failures from other processes
- The key technique for masking faults is *redundancy*

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Three kinds of redundancy

- Information redundancy
  - e.g., extra bits
- Time redundancy
  - e.g., redos after transaction aborts
- Physical redundancy
  - typical in biological systems

References I

Tanenbaum, A. S. and van Steen, M. (2007).
Distributed Systems. Principles and Paradigms.
Pearson Prentice Hall, Upper Saddle River, NJ, USA, 2nd edition.

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